CROCK:

Investigations of uncertainties in radio-nuclide transport processes in the far-field of a repository in crystalline rock

Thomas Rabung (KIT-INE)

EURADWASTE '13

8th EC Conference on the Management of Radioactive Waste

14-16 October 2013, Vilnius, Lithuania

Co-organised by

CROCK

Crystalline Rock Retention Processes

Duration: January 2011 – June 2013 (30 months)

Grant Agreement Number 269658

Overall Objective of the Project

Decreasing the uncertainty in the long-term prediction of the radionuclide migration in the crystalline rock far field (problem identified by national Waste Management Organizations)

- Selection of data for the disposal safety case: large spread in data

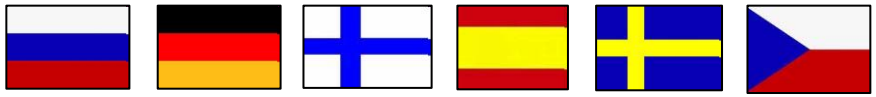
  → Experimental program reaches from nano-resolution to the PA relevant real site scale

- Increase of process understanding in the transport simulations, increasing confidence in PA

- Modeling includes testing up-scaling process and parameters for the application in PA

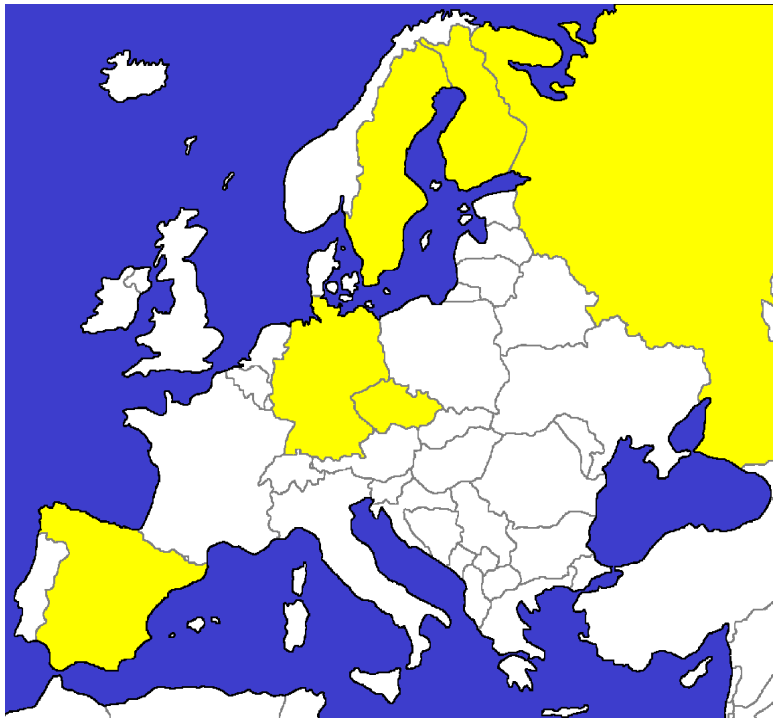
- Communication and dissemination to inform interested parties about the project and its outcome

CROCK Consortium



10 Beneficiaries
+
5 EUG members

from
6 different countries



Budget (contribution from EU):
1,057,927.4 €

CROCK beneficiaries

No	Name	Short Name	Country
1	Karlsruher Institut fuer Technologie	**KIT**	**Germany**
2	AMPHOS 21 CONSULTING SL	**AMPHOS**	**Spain**
3	CENTRE DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECHNOLOGICAS-CIEMAT	**CIEMAT**	**Spain**
4	Helmholtz-Zentrum Dresden-Rossendorf e.V.	**HZDR** *(formerly FZD)*	**Germany**
5	CHALMERS TEKNISKA HOEGSKOLA AB	**CTH**	**Sweden**
6	USTAV JADERNEHO VYZKUMU REZ A.S.	**UJV** *(formerly NRI)*	**Czech Republic**
7	CONTERRA AKTIEBOLOG	**CONTERRA**	**Sweden**
8	M V LOMONOSOV MOSCOW STATE UNIVERSITY	**MSU**	**Russian Federation**
9	TEKNOLOGIAN TUTKIMUSKESKUS VTT	**VTT**	**Finland**
10	KEMAKTA KONSULT AB	**KEMAKTA**	**Sweden**

End User Group (EUG):

The EUG is a group specifically set up within the project in order to represent the interests of the end users to the project and its desired outcome.

To this aim, the composition of the EUG includes organizations representing national waste management or national regulatory interests and competence.

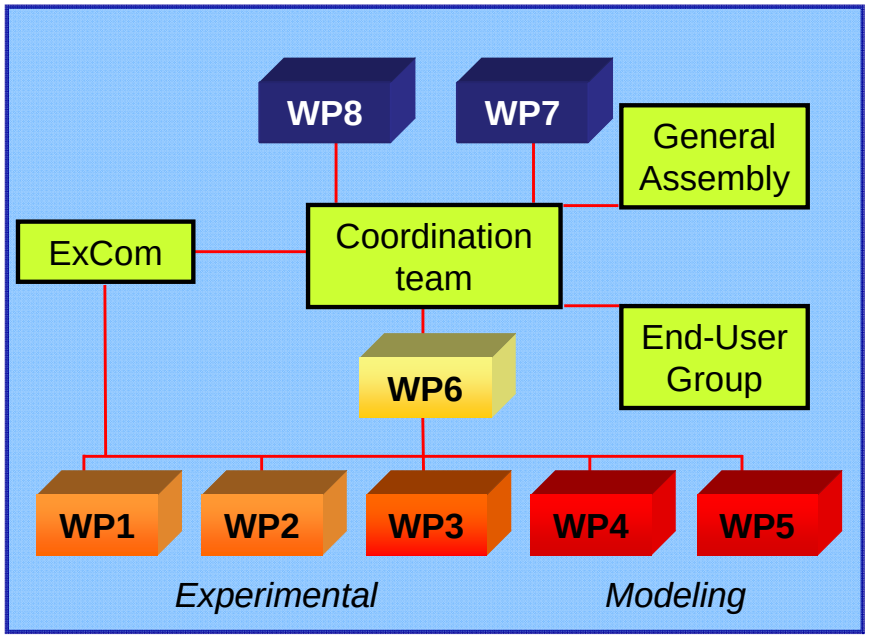
Their role will be to inform the project about the main strategic research interests of the end-users and on how the knowledge generated within the project should be formulated so that it can be integrated within the Safety Case.

SVENSK KÄRNBRÄNSLEHANTERING AB	SKB	Sweden
POSIVA OY	POSIVA	Finland
SPRÁVA ÚLOŽIŠŤ RADIOAKTIVNÍCH ODPADŮ	SURAO	Czech Republic
STRALSÄKERHERSMYNDIGHETEN	SSM	Sweden
RADIATION AND NUCLEAR SAFETY AUTHORITY	STUK	Finland

Management Structure and Procedures

***Coordination team*: Coordinator: KIT, Coordination Secretariat: AMPHOS 21.**

***End-User Group (EUG)*: consists of Waste Management Organizations and Regulators.**



ExCom:
all the WP leaders.

General Assembly:
represents all the beneficiaries.

WP 1: EXPERIMENTAL MATERIAL AND CHARACTERIZATION

- Organizing new drill-core samples from Äspö URL, sampled and handled under ***anoxic*** conditions. Samples from other sources (RUS, E, CH).

- Detailed chemical/mineralogical characterization, including structure and properties of accessible fluid systems (BET, porosity, hydraulic conductivities, CT data etc.)

- **Input to SC:** Usage of un-altered Äspö rock samples (for the first time): reflects the conditions in a repository after closure and is of special importance for redox-sensitive radionuclides.

Sampling and detailed characterization of site-specific biofilms from Äspö HRL for subsequent U(VI) and Np(V) sorption studies.

- **Input to SC:** Detailed knowledge on the behaviour of this material is of utmost importance for gaining trust on the Safety Case

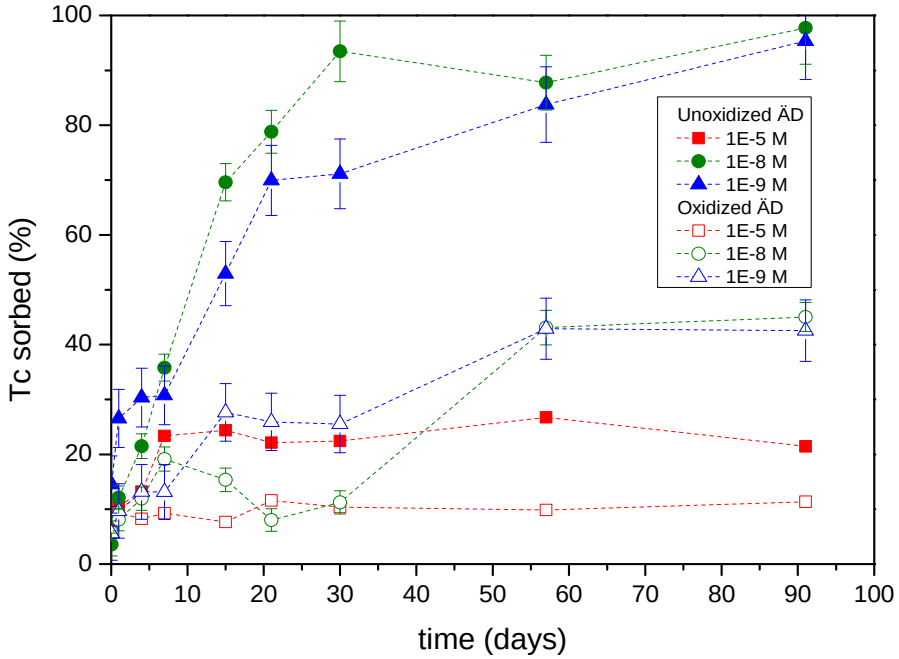
Rusty orange to brown Gallionella ferruginea dominated biofilms, attached to the fractured bedrock of the Äspö HRL tunnel.

WP 2: RADIONUCLIDE TRANSPORT AND SORPTION STUDIES

- Determination of radionuclide (U(VI), Tc(VII), Cs(I), Eu(III), Se(IV), Se(VI)) transport/sorption properties on crystalline rock systems over different spatial scales (small batch experiments to large block-scale).

- **Input to SC:** - New radionuclide sorption data on granite, comparison with granitic material from other sources: increase the confidence in exp. data and process understanding. In addition it also helps the modellers with the conceptualisation of retention processes.

- **Higher retardation for redox sensitive radionuclides (i.e. Tc) with a positive impact to SC.**

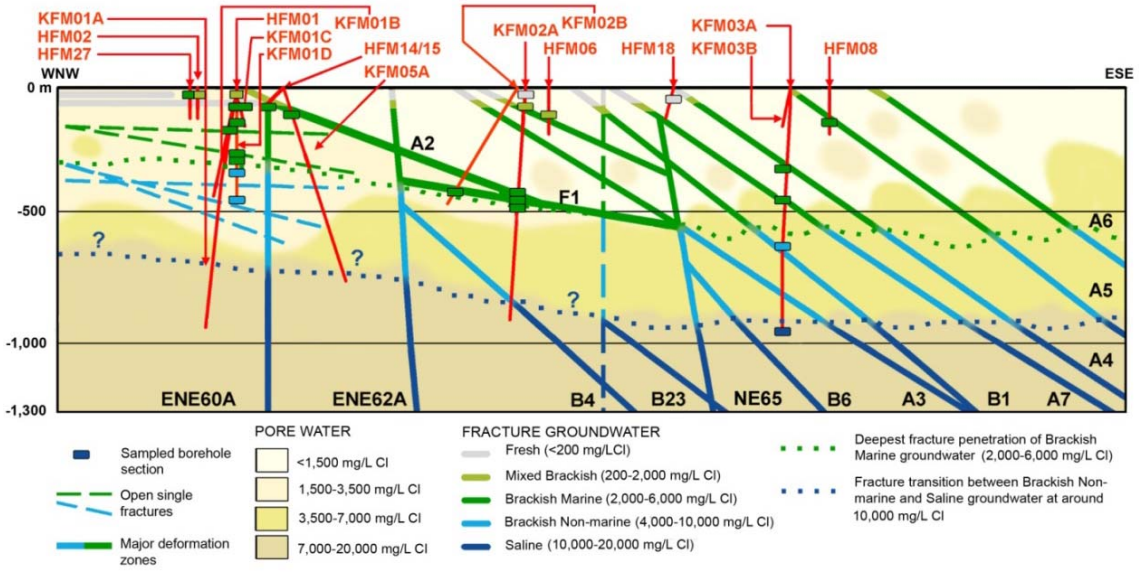


Tc sorption kinetics at different Tc concentrations on oxidized and un-oxidized Äspö diorite.

WP 3: REAL SYSTEM ANALYSIS

Assess the matrix diffusion processes based on natural inert tracer profiles away from fractured surfaces in real system samples (real time and spatial scales). Strongly related to the Swedish site characterization program. Use of an improved method for correcting the measurement data to remove the theoretical bias introduced by surface conduction.

Input to SC: providing upscaled values of diffusion length, porosity and diffusion coefficients.



Information to be used in other WP's

Forsmark site visualisation of the hydrochemical data along cross-section WNW-ESE.

WP 4: CONCEPTUALIZATION AND MODELLING

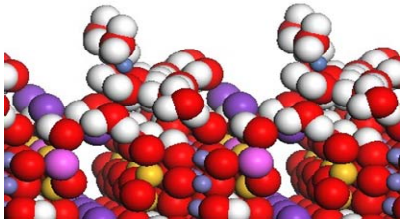
…related to radionuclide sorption/ transport processes on systems at different scales.

- Minimizing uncertainties in PA by developing and evaluating approaches for generating reliable data, improving the understanding of radionuclide migration and evaluating modeling approaches.

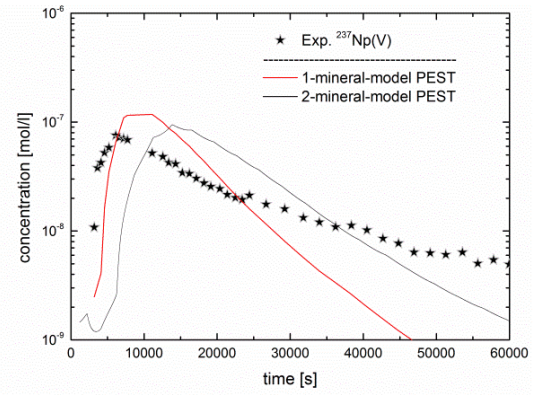
- Test consistency between different models ("top down", "bottom up" approaches) and approaches applicable to different spatial scales.

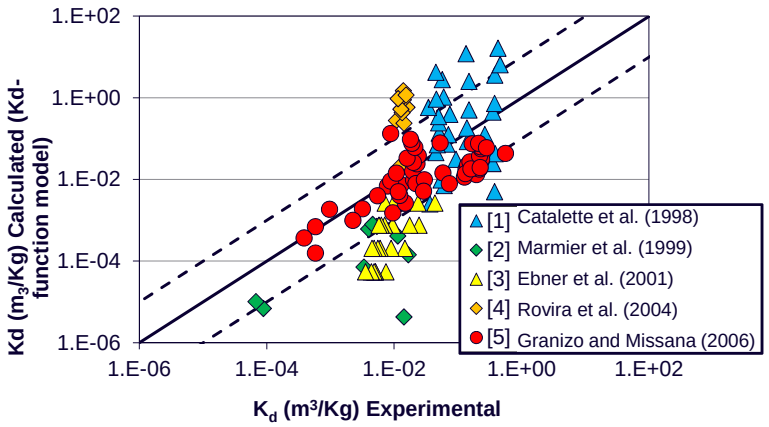
Input to SC: - Increased mechanistic understanding (sorption + transport processes) + reactive transport modelling.

- **Develop and evaluate methods for generating missing K_d- values.**



$S + 8\ H_2O + Ni(OH)H(H_2O)^{2+} + 2\ e^-$

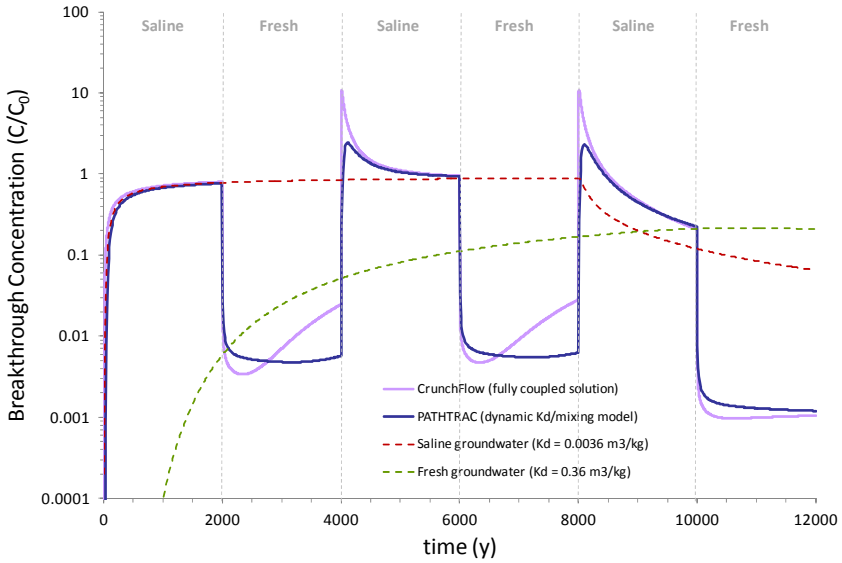




WP 5: APPLICATION TO THE SAFETY CASE

- Different methodologies/codes have been tested against a benchmark exercise.
- **Numerical tool (MCPhreeqc) have been developed** → Evaluate uncertainties in the parameters.
- A simplified modelling approach for the ion-exchanging solutes Ra, Sr and Cs has been successfully used (decreases computational limitations).
- Evaluation of the uncertainties on Kd values have been tested.

Input to SC: Development of approaches for conceptualizations and models for radionuclide retention processes improves the long-term predictions for the associated SC.



Comparison of breakthrough curves for Ra^{2+} migration simulated using PATHTRAC and a fully coupled reactive transport simulation using CrunchFlow

WP 6: DOCUMENTATION

- Compile and document the state-of-the-art on the transport and retention of radionuclides in the far-field at the beginning of the project as well as on the main conceptual models describing these processes available in the scientific literature

- Regular updating of the advances achieved within the project

WP 7: Knowledge Management, Dissemination and Training

- **WEB portal** of the project
  http://www.crockproject.eu/

- **Generic poster, 1st, 2nd and final report, publishable summary, annual newsletters etc.**

- **2 Annual Project Workshops** (including external participants):
  - May 2013 Karlsruhe (3 days) including poster session
  - May 2012 Stockholm (3 days) including poster session

  + 1 Kick-off Meeting (February 2011, Barcelona, 2 days)

Proceedings of the two Annual Workshops

(published as KIT Scientific Reports)

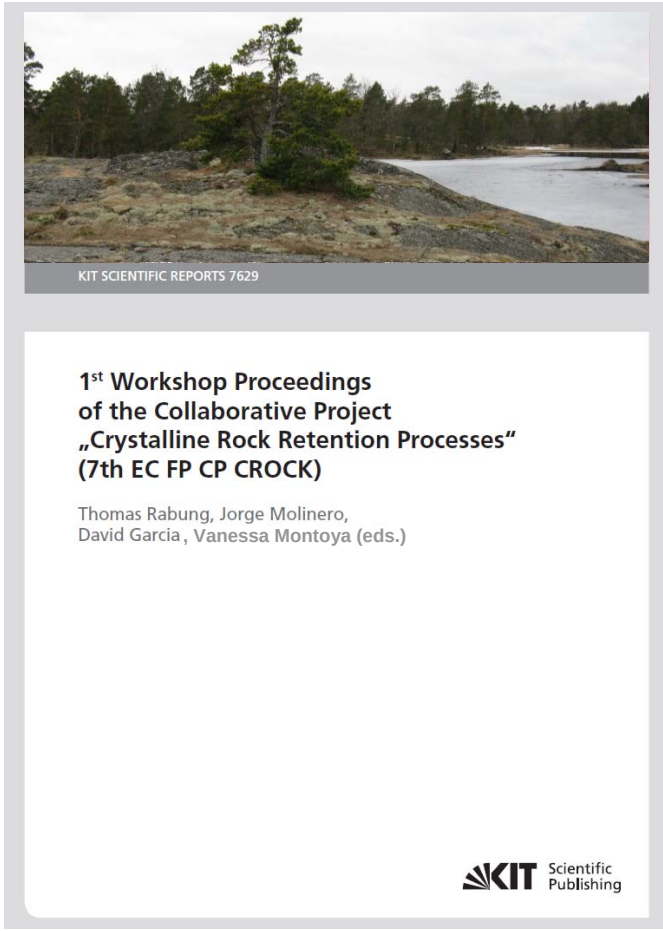
The proceedings will include

- scientific and technical contributions of **each beneficiary** **reviewed by the End-User** (38 contributions in total).

- summaries of the WP's

Proceedings will be made available to a broader community:

- download from the CROCK WEB page or as a KIT report (http://www.ksp.kit.edu)
- acquisition from AMAZON



Presentations at International Conferences

- International Conference on the Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere, in 2011 (Beijing, China) and 2013 (Brighton, UK)

- Goldschmidt 2013, (Florence, Italy, August, 2013)

- International Conference on Nuclear and Radiochemistry (Como, Italy, September, 2012)

-The EURADISS conference (Montpellier, France in October, 2012)

- *Interdisciplinary Physics with Ion Beams: Status and Perspectives - LNL Users Workshop*, (Legnaro, Italy, June 2011)

- *Ion Beams'12: Multidisciplinary Applications of Nuclear Physics with ions beams Conference*, (Legnaro, Italy, June 2012)

- 21st Conference on Ion Beam Analyses "IBA 2013", (Seattle, USA, June, 2013)

- 7th Russian Conference on Radiochemistry "Radiochemistry-2012" (Dimitrovgrad, Russia, October, 2012)

Training

- 10 PhD students + 4 postdocs are involved in the project

- 2 Topical sessions during the Annual Workshops:

  2012: “Reactive Transport Modelling”

  2013: “In situ URL experiments”

- Training course of a postdoc (3 months) about reactive transport modelling at Amphos 21

CONCLUSIONS

Statements of the end users at the end of the project:

- The project keeps up the knowledge and the expertise achieved in the past. This could be useful for other countries with emerging DGR projects, which could be trained on this issue in the future.
- The project keeps crystalline rock research in an international environment of cooperation, helping European researchers to work together.
- The project favored active discussions among different research groups and this is helpful for advancing in the knowledge and characterization of the studied systems.
- The project had run very well without major problems in delivering the work.

OUTLOOK

Based on the recommendations from the end-user:

- The role of $O_2(g)$ intrusion in the system during the operation phase of the repository.
- The (unknown) role of anion exclusion.
- An improved characterization of the rock porewater, not water in the fractures.
- Necessity of new knowledge about in-situ porosity, diffusivity, etc.
- Possibility of in-situ experiments in Äspö and Onkalo, relevance of large scale experiments.
- Extension to the near field: use of SIMFUL in URL and spent fuel in the lab

Presentation at the IGD-TP Exchange Forum 29.-30. October 2013, Prague

Thank you for your attention !